Early Adoption of ESMF by Land Information System (LIS)

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Land Information System (LIS)

- Objective: To develop a global, high resolution, observation-driven, land modeling and data assimilation system
- Benefits: Enable improved land-atmosphere understanding, hydrological and climate prediction
- Applications:
  - Weather and climate model initialization and retrospective coupled modeling
  - Water resources management
  - Agricultural forecasting, etc.

LIS

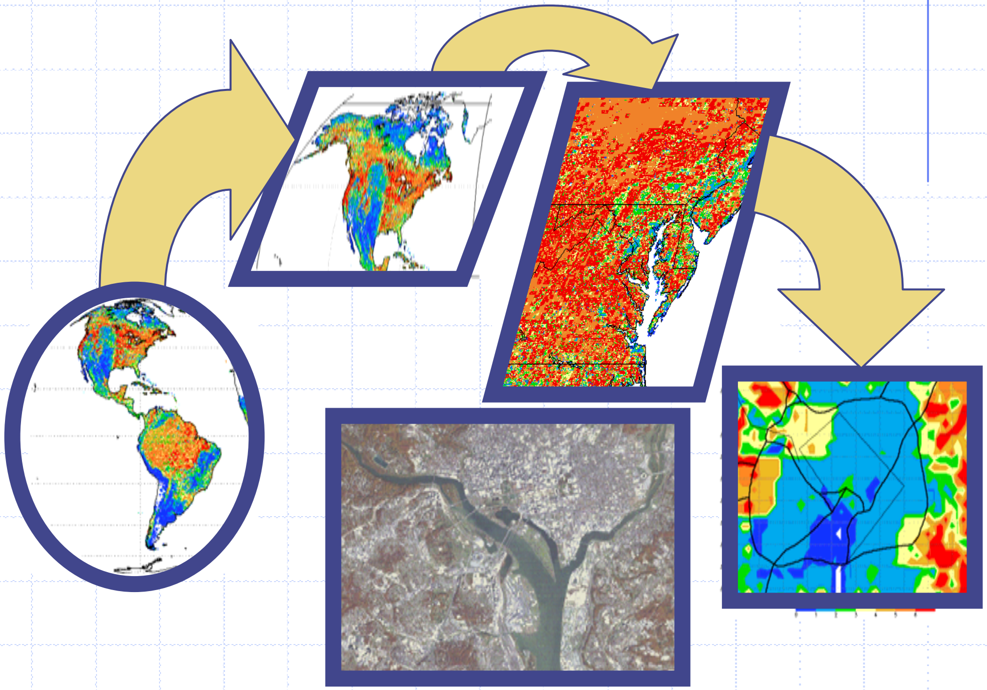
- When complete LIS will..
  - Operate in near-real-time at a high spatial (up to 1km) and temporal (15 min) resolution;
  - Predict and assimilate global fluxes/stores of water and energy
  - Exploit scalable high performance computing technologies to operate at high resolutions.
  - Interoperate with other earth system modeling standards

Land Surface Modeling in LIS

- Land Modeling
  - Use multiple, state-of-the art water-energy-carbon land modeling systems (CLM, NOAH, VIC)
  - Land models are forced with
    - Real-time output from numerical models
    - Best available observed data from surface and remotely sensing platforms

Computational Challenges

- Computational Requirements increase significantly at high resolution
  - Approximately 2-3 months to simulate a day at 15 minute timesteps globally at 1km
  - Memory requirements in the order of terabytes

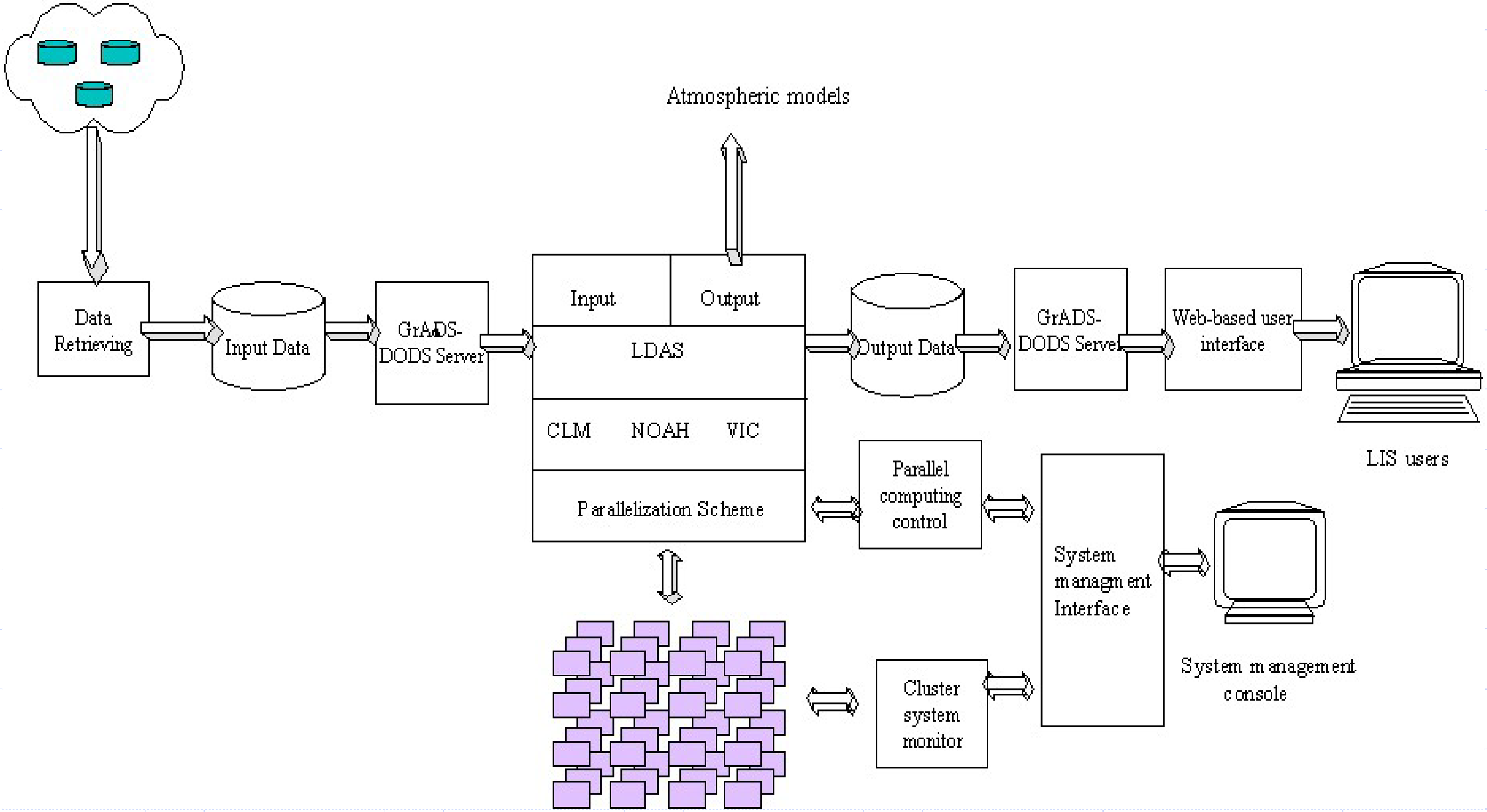


Resolution	1/4 deg	5 km	1 km
Land Grid Points	2.43E+05	5.73E+06	1.44E+08
Disk Space/Day (Gb)	1	28	694
Memory (Gb)	3	62	1561

High Performance Computing in LIS

- Land surface processes have weak horizontal coupling on short time and large space scales
- LIS uses this inherent parallelism to achieve highly efficient scaling
- Use of GrADS-DODS(GDS) server's capabilities to handle memory requirements
  - Parallel I/O
  - Subsetting capabilities

LIS Architecture



http://lis.gsfc.nasa.gov

LIS Cluster

8 IO/storage nodes, Dual AMD CPU

192 Compute nodes, single AMD CPU

112 GB Total memory

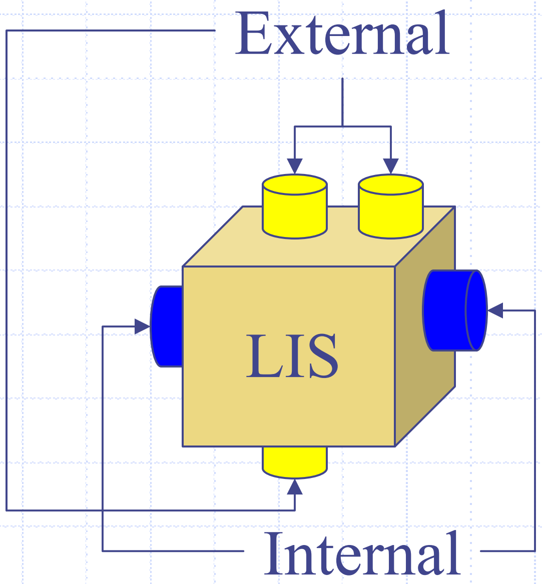
22 TB Total disk storage

10 1000Mbps Ethernet links

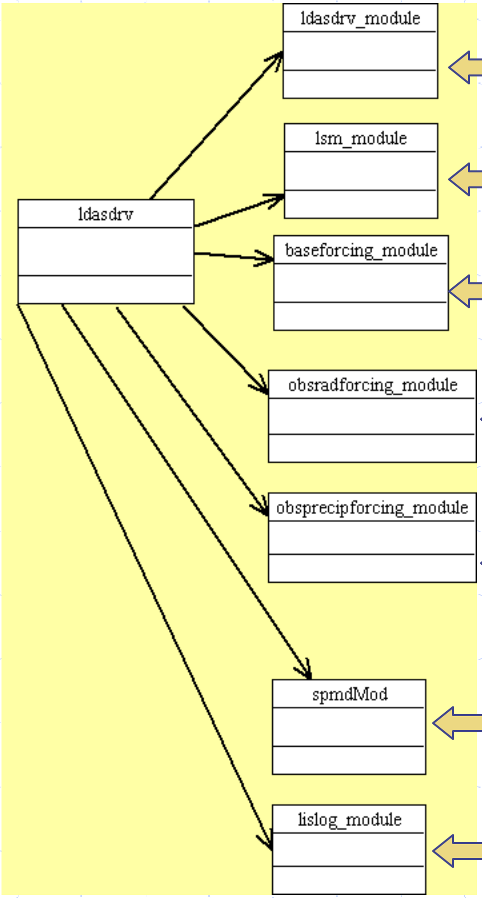
192 100Mbps Ethernet links

Interoperability in LIS

- Internal
  - Interfaces that LIS provides for researchers in the community
  - For incorporating new LSMs, Using input/output from LIS
- External
  - Interfaces that LIS adopts for participating with other earth system modeling groups
    - Complying with existing standards such as ALMA
    - Adopt the utilities and compliance guidelines provided by ESMF



Modular Design in LIS



Main Driver behavior

Land Surface Model behavior

Model forcing behavior

Observed Radiation forcing behavior

Observed Precipitation forcing behavior

Parallel environment control

Error Log Diagnostic control

Internal interoperability in LIS

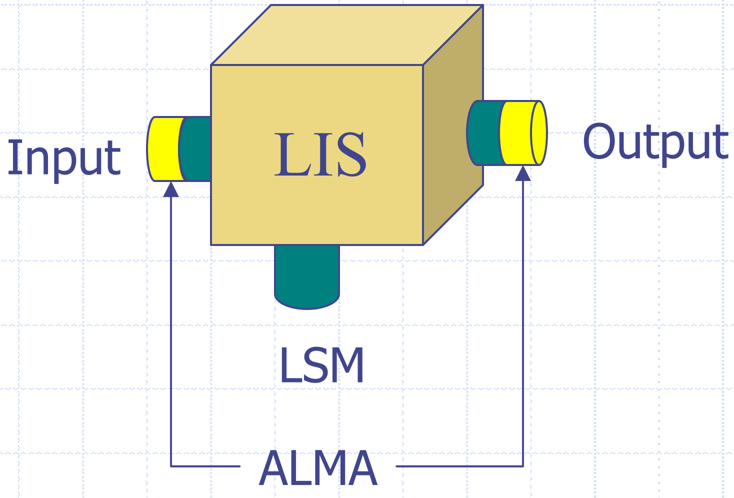
- Enables reuse of broad set of data
- Allows for easy intercomparisons of different land models
- Enables the reuse of high performance computing infrastructure, data assimilation and other tools.

External Interoperability in LIS

- Interoperability with other scientific modeling communities
- ALMA (Assistance for Land Modeling Activities)
- ESMF (Earth System Modeling Framework)

Assistance for Land Modeling Activities (ALMA) (http://www.lmd.jussieu.fr/ALMA)

- Data exchange convention to facilitate exchange of forcing data for LSMs and results produced by these schemes
- Enables intercomparisons of LSMs.
- Provides list of variables needed to force LSMs and a summary of output variables for LSM intercomparisons.



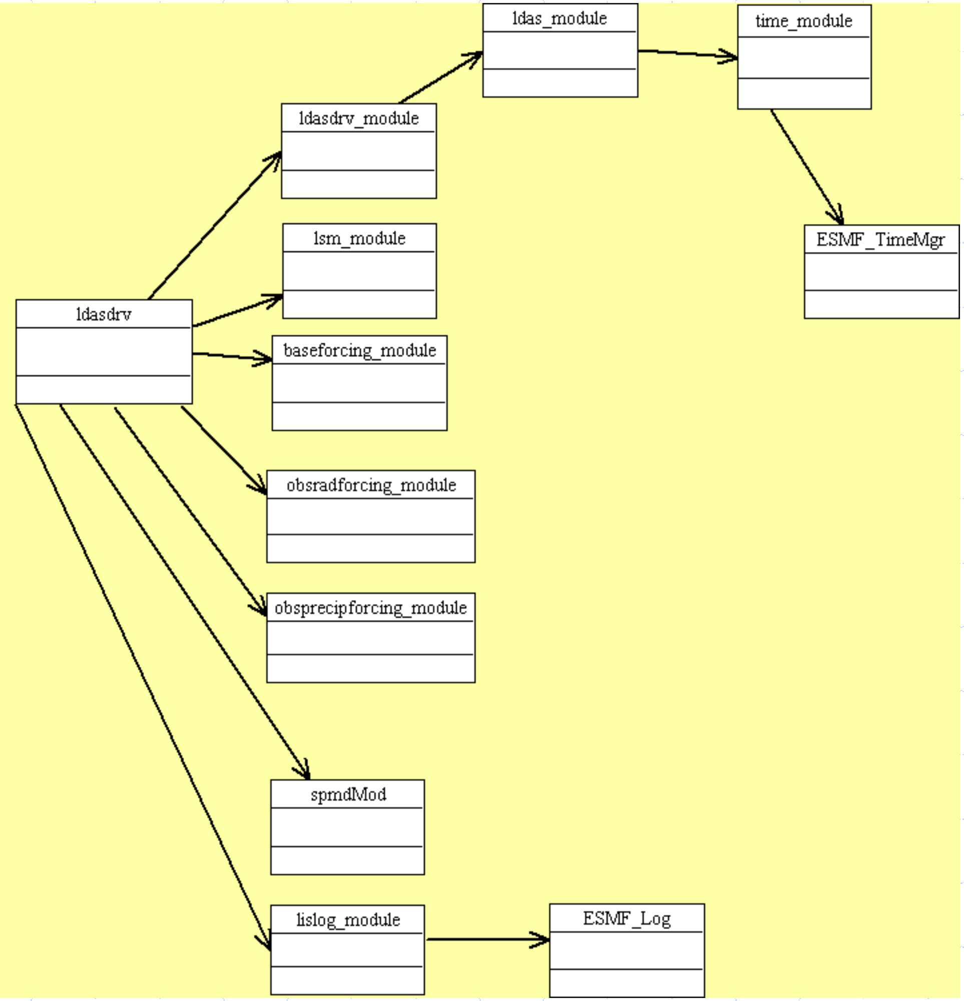
ESMF

- Structured collection of building blocks that can be customized to develop model components
- Superstructure for coupling and running different model components
- Infrastructure of utilities and data structures for building model components

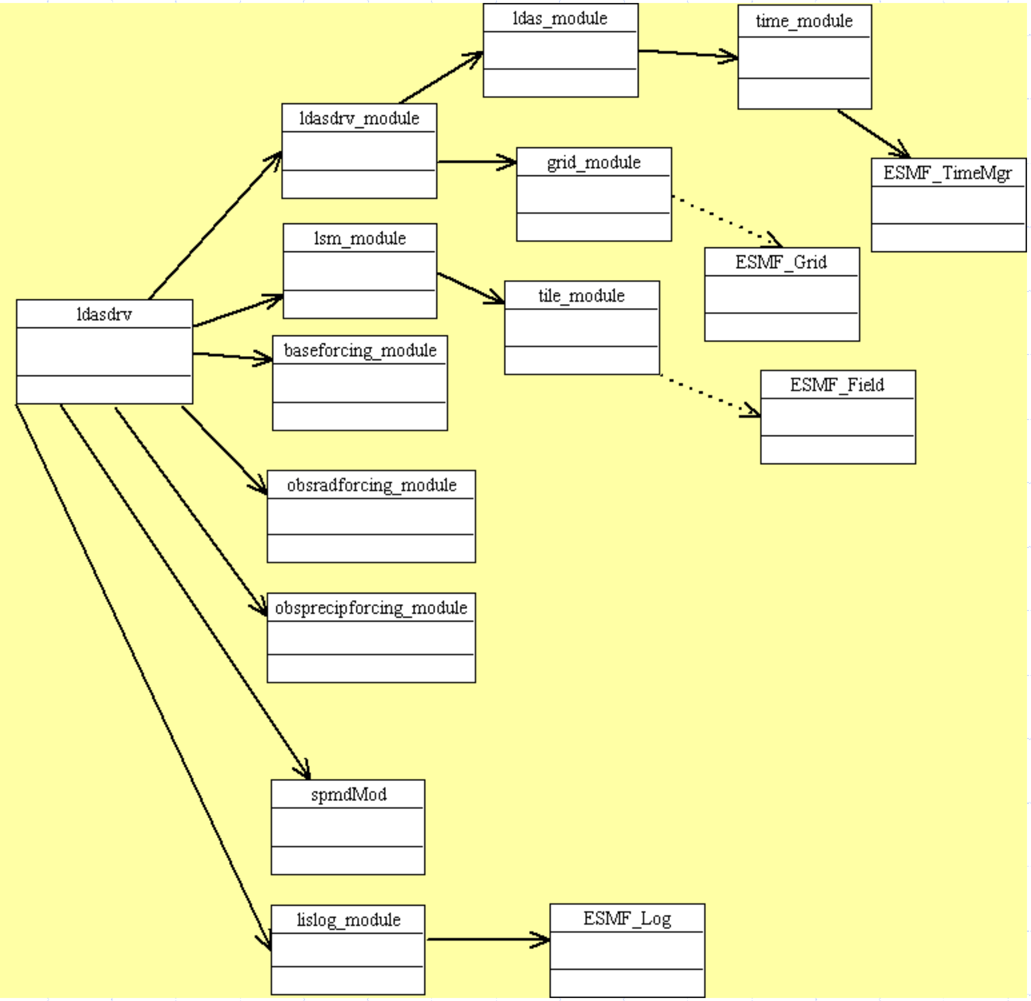
LIS and ESMF Infrastructure

- Infrastructure utilities currently in LIS:
  - ESMF Time Manager
    - Functions for time calculations
    - Tools for model time stepping and alarms
  - ESMF Error/Log diagnostic tools
    - Organizes diagnostic output

LIS and ESMF Infrastructure (contd.)



LIS and ESMF Infrastructure (contd.)



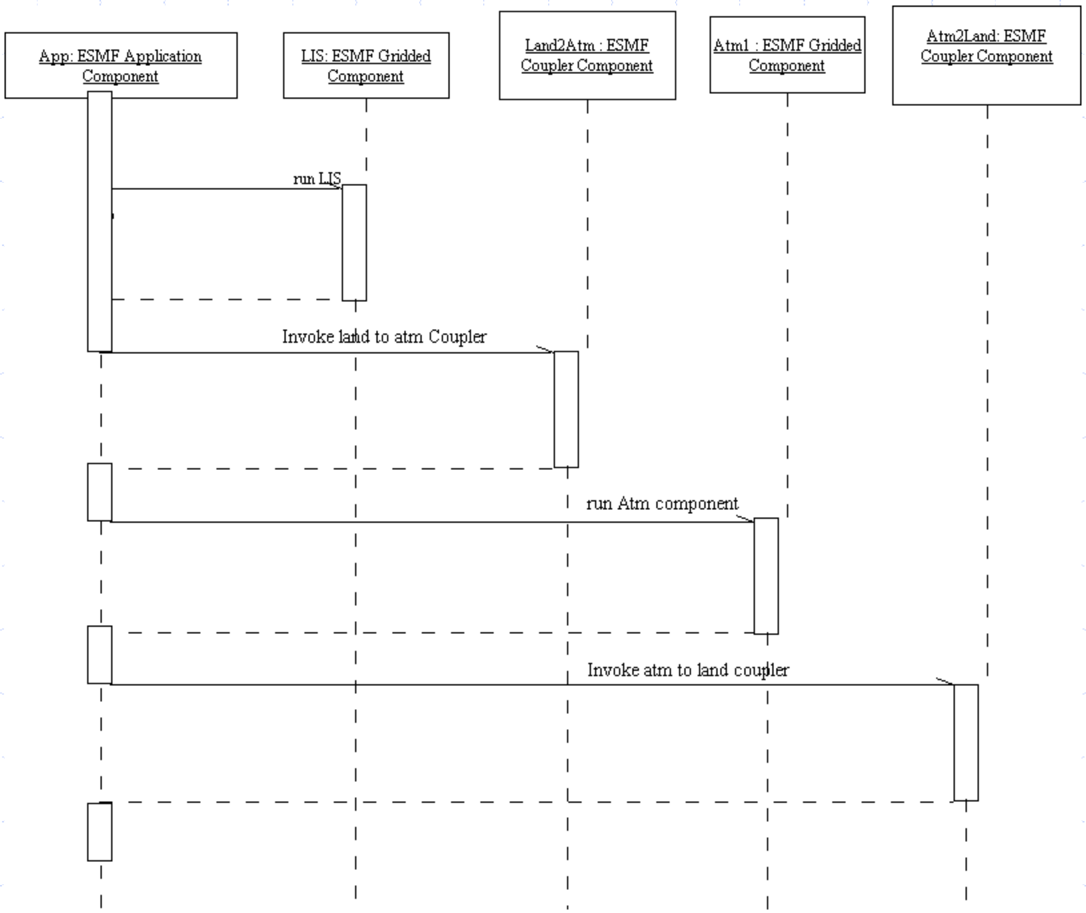
LIS and ESMF Infrastructure – Future plans

- Adapt abstractions of fields and group of fields necessary for implementing coupled applications.
- Implement infrastructure utilities as they become available
  - Regrid, IO, basic communications

LIS and ESMF Superstructure

- Gridded Component : user components discretized on grids
- Coupler Component : software that couples gridded components.
- LIS will be implemented as a gridded component
  - No need to make each LSM a gridded component
  - LIS could act as the land modeling component in a coupled system

LIS and ESMF Superstructure (contd.)



Summary

- LIS and ESMF – Evolving Systems
- LIS provides a land modeling infrastructure for high resolution modeling
- The use of ESMF enables code reuse, interoperability with other earth system models